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jc490 U.S. PTO

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Ronnie Davis
Signature

jc518 U.S. PTO
09/287028
04/06/99

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Atty. Dkt. No.: NRWB:002--2

Prior Application Examiner:
Edward Lefkowitz

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Classification Designation:
340-310.020

Prior Group Art Unit: 2736

REQUEST FOR FILING CONTINUATION APPLICATION
UNDER 37 C.F.R. § 1.53(b)

This is a request for filing a continuation application under Rule 53(b) (37 C.F.R. § 1.53(b)) of co-pending prior application Serial No. 08/826,983 filed April 9, 1997, entitled "Transmission Network and Filter Therefor."

- ☒ 1. Enclosed is a copy of the prior application Serial No. 08/826,983 as originally filed, including specification, claims, drawings, and declaration. The original signed declaration is found in application Serial No. 08/347,427, which is the U.S. national phase of PCT/GB93/02163. The undersigned hereby verifies that the attached papers are a true copy of the prior application as originally filed and

identified above, that no amendments (if any) referred to in the declaration filed to complete the prior application introduced new matter therein, and further that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statement may jeopardize the validity of the application or any patent issuing thereon.

(a) ☒ The inventorship is the same as prior Application Serial No. 08/826,983.

(b) ☐ Deletion of inventor(s). Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. § 1.63(d)(2) and 1.33(b).

☒ 2. Enclosed is a check in the amount of \$1,234 to cover the filing fee as calculated below and the fee for any new claims added in the Preliminary Amendment referred to in Clause No. 8 below.

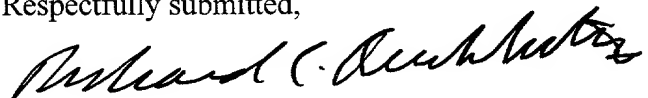
CLAIMS AS FILED IN THE PRIOR APPLICATION
LESS CLAIMS CANCELED BELOW

FOR	NUMBER FILED	NUMBER EXTRA	RATE	FEE
Basic Fee -----				\$790.00
Total Claims	29 - 20 =	9 X	\$22.00 =	\$198.00
Independent Claims	6 - 3 =	3 X	\$82.00 =	\$246.00
Multiple Dependent Claim(s) -----				\$-0-.00
TOTAL FILING FEES:				\$1234.00

- ☐ 3. Applicant is entitled to Small Entity Status for this application.
- ☐ (a) A small entity statement is enclosed.
- ☐ (b) A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.
- ☐ (c) Small entity status is no longer claimed.
- ☒ 4. If the check is missing or insufficient, the Assistant Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16 to 1.21 which may be required for any reason relating to this application, or credit any overpayment to Arnold White & Durkee Deposit Account No. 01-2508/NRWB002--2.
- ☒ 5. Enclosed is a copy of the current Power of Attorney in the prior application; it is combined with the inventor's declaration.
- ☒ 6. Address all future communications to:
- Richard C. Auchterlonie
ARNOLD WHITE & DURKEE
P. O. Box 4433
Houston, Texas 77210
(713) 787-1400
- ☒ 7. The prior application is presently assigned to Norweb plc.
- ☒ 8. Enclosed is a preliminary amendment. Any additional fees incurred by this amendment are included in the check at No. 2 above and said fee has been calculated after calculation of claims and after amendment of claims by the preliminary amendment.
- ☒ 9. Cancel in this application claims 2 to 8 of the prior application before calculating the filing fee. (At least one original independent claim must be retained).

- ☒ 10. Amend the specification by inserting before the first line the sentence: --This is a continuation of co-pending application Serial No. 08/826,983 filed April 9, 1997, which is a continuation of application Serial No. 08/347,427 filed November 29, 1994 (35 U.S.C. § 371 filing of PCT/GB93/02163 filed October 20, 1993)--.
- ☒ 11. Priority of foreign patent application number GB9222205.08, filed on 22 Oct. 1992 in Great Britain is claimed under 35 U.S.C. § 119(a)-(e). The certified copy has been filed in the prior grand-parent application Serial No. 08/347,427.
- ☒ 12. Enclosed are formal drawings (nine sheets).
- ☒ 13. An Information Disclosure Statement (IDS) is enclosed.
- ☒ (a) Copies of PTO-1449 by Applicant and by Examiner in the parent application, which have been renumbered with consecutive page numbers.
- ☒ (b) Copies of the references cited are found in the parent application, or the grand-parent application.
- ☒ 14. Request for Permission to Amend Drawings.
- ☒ 15. Return Receipt Postcard (should be specifically itemized).

Respectfully submitted,



Richard C. Auchterlonie
Reg. No. 30,607
Attorney for Applicant

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P.O. Box 4433
Houston, Texas 77210-4433
(713) 787-1400

Date: 6 April 1999

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

U.S. SERIAL NO.: _____

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GROUP ART UNIT:

FILING DATE: _____

EXAMINER:

APPLICANT: Paul A. Brown

ATTY. DKT.: NRW:002--1

ORIGINAL TITLE:

TRANSMISSION NETWORK
AND FILTER THEREFOR

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Please amend the above-identified application as follows:

In the Title:

Please change the title to -- Electricity Distribution
and/or Power Transmission Network and Filter for
Telecommunication over Power Lines --.

In the Specification:

On page 1, after the title and between lines 1 and 2, please
insert the heading:

--

BACKGROUND OF THE INVENTION

1. Technical Field

--.

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On page 1, line 4, please change "network ie." to
--network; i.e., --.

On page 1, after the end of the first paragraph and between
lines 8 and 9, please insert the heading:

--

2. Background Art

--.

On page 1, line 10, please change "33kv" to --33kV--.

On page 1, line 11, please change "33kv" to --33kV--.

On page 1, line 11, before "distribution network" please
insert --"--.

On page 1, lines 14 to 15, please change "all networks" to
--all such networks --.

On page 1, line 23, after "control", please insert --,--.

On page 2, line 4, please change "6KHz" to --6kHz--.

On page 2, line 4, please change "148KHZ" to --148kHz--.

On page 2, line 26, please change both occurrences of "KHz"
to --kHz--.

On page 2, line 29, please change both occurrences of "KHz"
to --kHz--.

On page 2, line 34 (the last line on the page), please
change "240v" to --240V--.

On page 3, between paragraphs between lines 10 and 11,
please insert the heading:

--

SUMMARY OF THE INVENTION

--.

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On page 3, line 24, please cancel the second occurrence of "network".

On page 3, line 30, please change "800KHz" to--800kHz--.

On page 3, line 30, please change "600Hz" to --600kHz--.

On page 4, line 1, please change "415v" to --415V--.

On page 4, line 2, please change "11kv" to --11kV--.

On page 4, line 8, please change "132kv, 33kv, 11kv, 415v, 240v" to --132kV, 33kV, 11kV, 415V, 240V--.

On page 5, line 19, please change "240v, 50HZ" to --240V, 50Hz--.

On page 6, lines 15 to 18, please cancel "each end thereof to a signal input/output line which is arranged in parallel to the mains electricity input and mains electricity output, the two connections including a first capacitor and a second capacitor", and substitute in its place --the mains electricity input end to a first capacitor and at the mains electricity output end to a second capacitor. The first capacitor connects the mains electricity input to a signal input/output line, and the second capacitor connects the mains electricity output to ground. The first and second capacitors are --.

On page 6, line 25, before "for frequencies", please insert --which is appropriate--.

On page 6, line 32 (the third line from the bottom of the page), please change "the signal input/output line" to --ground--.

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On page 6, lines 33 to 34 (the last two lines on the page), please cancel "and is connected via the signal input/output line to ground."

On page 7, line 2, after "fuse", please insert ---.

On page 7, lines 3 and 4, please cancel "arranged between the first or second capacitor and the signal's input/output line", and insert in its place --The fuse of the first capacitor is connected in series with the first capacitor between the mains electricity input and the signal input/output line. The fuse of the second capacitor is connected in series with the second capacitor between the mains electricity output and ground--.

On page 7, line 21, please cancel "the signal input/output line and".

On page 7, line 30, please change "of" to --or--.

On page 8, before line 1, please insert the heading:

-- BRIEF DESCRIPTION OF THE DRAWINGS ---

On page 8, between lines 21 and 22 (just before the last paragraph beginning on the page), please insert the heading:

-- DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS ---

On page 8, line 23, please change "11kv" to --11kV--.

On page 8, line 24, please change both occurrences of "415v" to --415V--.

On page 9, line 6, please change "voltage" to --frequency--, and after "power signal", please insert --,--.

On page 10, line 16, please change "240v" to --240V--.

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On page 11, line 7, please change "includes" to --is connected to--.

On page 11, line 33 (third line from the bottom of the page), after "box 90", please insert --and mounted on a conductor clamp 91 --.

On page 12, line 10, please change "element." to --unit. Shown in FIG. 10 is a terminal 87 for connection to an electricity distribution or transmission phase conductor, an output terminal 88 for connection to a single phase feed, and a communication port terminal 89. --

On page 12, line 14, please change "50/60HZ" to --50/60Hz--.

On page 12, line 25, please change "dependant" to --dependent--.

On page 13, line 13, after "comprise", please cancel "of".

On page 13, line 15, please change "240, 415, 11kv, 33kv" to --240V, 415V, 11kV, 33kV--.

On page 14, line 4, please change please change "240v" to --240V--.

On page 14, line 4, please change please change "415v" to --415V--.

In the Claims:

Please cancel claim 1.

Claims 2 to 8 have been cancelled by the request for filing this continuation application.

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Please and add new claims 9 to 48 as follows:

-- 9. A polyphase electricity distribution and/or power
1 transmission network comprising:

2 a plurality of phase conductors;

3 input means for input of a telecommunication signal having a
4 carrier frequency greater than approximately 1MHz onto at least
5 one of the phase conductors of the network; and

6 output means for removing the telecommunication signal from
7 at least one other phase conductor of the network.

1 10. The network as claimed in claim 9, wherein said
2 telecommunication signal is transmissible over the network in a
3 plurality of directions simultaneously.

1 11. The network as claimed in claim 9, wherein the carrier
2 frequency is within the range of 1MHz to 60MHz.

1 12. A network according to claim 9, wherein the network
2 connects a plurality of separate buildings and said
3 telecommunication signal is transmissible between said buildings.

1 13. The network as claimed in claim 9, wherein the
2 telecommunication signal propagates between at least one of the
3 phase conductors of the network and ground.

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1 14. A network according to claim 13, wherein the input
2 means is for the input of the telecommunication signal onto only
3 one of the phase conductors.

1 15. A trunk and branch multipoint electricity distribution
2 and/or power transmission network including input means for input
3 onto the network of a telecommunication signal having a carrier
4 frequency greater than approximately 1MHz and output means for
5 removing the telecommunication signal from the network.

1 16. The network as claimed in claim 15, wherein said
2 telecommunication signal is transmissible over the network in a
3 plurality of directions simultaneously.

1 17. The network as claimed in claim 15, wherein the carrier
2 frequency is within the range of 1MHz to 60MHz.

1 18. A network according to claim 15, wherein the network
2 connects a plurality of separate buildings and said
3 telecommunication signal is transmissible between said buildings.

1 19. A network according to claim 15, including three phase
2 conductors wherein said input means is for the input of said
3 telecommunication signal onto one of the phase conductors and

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4 said output means is for removing said telecommunication signal
5 from at least one other phase conductor.

1 20. A network according to claim 19, wherein the input
2 means is for the input of the telecommunication signal onto only
3 one of the phase conductors.

1 21. The network as claimed in claim 15, wherein the
2 telecommunication signal propagates between a phase conductor of
3 the network and ground.

1 22. An electricity distribution and/or power transmission
2 network at least part of which is external to a building, the
3 network including input means for input onto the network of a
4 telecommunication signal having a carrier frequency greater than
5 approximately 1MHz and output means for removing the
6 telecommunication signal from the network, the telecommunication
7 signal being transmissible along the external part of the
8 network.

1 23. The network as claimed in claim 22, wherein
2 telecommunication signals are transmissible over the network in a
3 plurality of directions simultaneously.

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1 24. The network as claimed in claim 22, wherein the carrier
2 frequency is within the range of 1MHz to 60MHz.

1 25. A network according to claim 22, wherein the network
2 connects a plurality of separate buildings and said signal is
3 transmissible between said buildings.

1 26. A network according to claim 22, including three phase
2 conductors wherein said input means is for the input of said
3 telecommunications signal onto one of the phase conductors and
4 said output means is for removing said telecommunication signal
5 from at least one other phase conductor.

1 27. A network according to claim 26, wherein the input
2 means is for the input of the signal onto only one of the phase
3 conductors.

1 28. The network as claimed in claim 22, wherein the
2 telecommunication signal propagates between a phase conductor of
3 the network and ground.

4 29. A method of signal transmission including:
5 transmission of a telecommunication signal having a carrier
6 frequency of greater than approximately 1MHz onto at least one

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7 phase conductor of a polyphase electricity distribution and/or
8 power transmission network; and

9 subsequent reception of the telecommunication signal from at
10 least one other phase conductor of the network.

1 30. The method as claimed in claim 29, wherein the
2 telecommunication signal is injected onto only one of the phases
3 of the network.

1 31. The method as claimed in claim 29, wherein
2 telecommunication signals are transmitted over the network in a
3 plurality of directions simultaneously.

1 32. The method as claimed in claim 29, wherein the
2 telecommunication signal is modulated using a spread spectrum
3 technique.

1 33. A method of signal transmission including input of a
2 telecommunication signal having a carrier frequency of greater
3 than approximately 1MHz onto a trunk and branch multipoint
4 electricity distribution and/or power transmission network, and
5 subsequent reception of the telecommunication signal.

1 34. A method of signal transmission including input of a
2 telecommunication signal having a carrier frequency of greater

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3 than approximately 1MHz onto an electricity distribution and/or
4 power transmission network at least part of which is external to
5 a building and subsequent reception of the telecommunication
6 signal, the telecommunication signal being transmitted along the
7 external part of the network.

1 35. The method as claimed in claim 34, wherein the network
2 is a polyphase network, and the telecommunication signal is
3 injected onto only one phase of the network.

1 36. The method as claimed in claim 34, wherein
2 telecommunication signals are transmitted over the network in a
3 plurality of directions simultaneously.

1 37. The method as claimed in claim 34, wherein the
2 telecommunication signal is modulated using a spread spectrum
3 technique. --

In the Drawings:

Filed herewith is a separate letter addressed to the
Official Draftsperson requesting approval of amendments to FIGS.
1, 8, 9 and 10 and showing the requested changes in red on
sketches submitted in triplicate.

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REMARKS

The amendments to the specification and drawings are intended to be the same amendments that have been made in the grand-parent application Ser. No. 08/347,427. The correspondence between the new claims above and the claims in the parent application should be as follows:

<u>New Claims</u>	<u>Ser. No. 08/826,983</u>
9-28	9-28
29-33	33-37
34-37	45-48

Signed at Houston in the County of Harris, and State of Texas, this 6th day of April, 1999.

Respectfully submitted,

Richard C. Auchterlonie
Richard C. Auchterlonie
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Bonnie Davis
Signature

TRANSMISSION NETWORK AND FILTER THEREFOR

This invention relates to a method of signal injection, transmission, interconnection (termination), and detection, and to a power transmission network ie. a mains electricity distribution and/or transmission network, and a filter therefor. In particular it relates to the use of electricity transmission networks and/or lines for telecommunications transmission (e.g. voice and/or data).

In the UK, it is conventional to describe a power network for 33kv and above as a "transmission network", and one for less than 33kv as a distribution network". In this specification the term "electricity distribution and/or power transmission network" is normally used, but general references to power networks and to transmission of signals are to be construed as applying to all networks.

Traditionally telecommunications signals have been transmitted on independent networks e.g. telephone lines - more recently, in order to simplify and increase efficiency of telecommunications services to domestic or industrial premises, there have been investigations into using existing electricity transmission and distribution networks to carry telecommunications services.

It has been known to utilise above ground (overhead) power lines for the transmission of additional control speech and data signals. However, with such transmissions, the frequency spectrum must be allocated for and restricted to particular applications in order to avoid interference with other telecommunications services. In addition, the strength of signals which can be transmitted is limited since the amount of radiation produced by the transmission is related to the strength of the signal and this radiation must be kept to a minimum.

Such transmission signals must therefore be of low power and confined within a specific frequency band allocated by international agreement for such purposes, so this mechanism is unsuitable for large scale voice and/or data transmission where

signals extend well into the radio spectrum (e.g. 150 kHz and above).

It has been known to use spread spectrum techniques to transmit data at carrier frequencies of between 6KHz and 148KHz on underground and overhead power networks. Again, in this allocated frequency band such transmissions suffer from low data rates and low traffic capacities due to power line noise characteristics. Due to the limited spectrum available and high noise levels encountered wideband telecommunication signals cannot be sent.

Although papers such as J.R. Formby and R.N. Adams, "The mains network as a high frequency signalling medium", The Electricity Council, January 1970, suggested a communications potential for the low and medium voltage networks no further work was undertaken. Even today, with the prospect of remote meter reading and selective load control, solutions tend to employ techniques such as telephony and radio communications, thus avoiding the mains network where possible.

Ideas have been put forward but few have proceeded past the theoretical stage, due to the hostile environment presented by the mains network. The problems to overcome include electrical noise, (both constant background noise and transient spikes) and high attenuation of high frequency signals due to skin and proximity effects.

Messrs Formby and Adams suggested using frequencies in the range of 80 to 100 KHz. 100 KHz was recommended as a maximum because theory suggested that higher frequencies would suffer from excessive attenuation. Other papers recommend a maximum of 150 KHz due to the fact that radiated signals higher than 150 KHz would interfere with broadcast radio signals.

A further situation where power networks are also used for the transmission of speech and data signals is on the electricity wiring inside buildings. In such configurations the internal 240v mains wiring is used for the transmission of data, with

appropriate filtering being provided to add and separate the data signals from the power signals. Additionally a filter, such as the Emlux filter described in European Patent Application 141673, may be provided to prevent data signals leaving the building and entering the power supply network external to the building. The Emlux filter described consists of a tuned ferrite ring which acts effectively as a band stop filter. In order to be effective the band stop filter must be of narrow band width and therefore is not suitable for use with high speed data communications, since a large number of such band stop filters would be required.

The present invention aims to provide a transmission network which alleviates some or all of the above problems.

Accordingly, in a first aspect, the present invention provides a power transmission and/or distribution network including input means for the input of a telecommunication signal having a carrier frequency greater than approximately 1MHz onto the network, (e.g. an underground electricity transmission and/or distribution network), and output means for removal of similar telecommunication signal from the network.

Contrary to the teachings of the prior art, use of carrier frequencies of this magnitude is not impractical due to attenuation effects. This is because, at these higher frequencies, the cables of the power transmission and/or distribution network network exhibit pseudo-coaxial characteristics and therefore attenuation is reduced.

In this way both speech and data signals can be transmitted at carrier frequencies of greater than approximately 1MHz allowing for a larger available spectrum and greater transmission capacity. The carrier frequency may in fact be less than 1MHz ie. 800KHz or even as low as 600Hz, but as it is reduced so is the bandwidth.

The term "carrier frequency" refers to the unmodulated frequency of the carrier signal, and not to the frequency of the telecommunication signal once modulated.

On, for example, a 415v network the carrier frequency may preferably be between 1-10MHz, and on, eg., a 11kv network may be between 5-60MHz. However the frequency may be up to 100's of MHz depending on the network and the application. For example, over short distances (10-20m) a frequency range of 1-800MHz may be used.

Preferably the power network is a major underground power network including e.g. 132kv, 33kv, 11kv, 415v and 240v sections. The voice and data signals may be transmitted over any or all of the sections of the power network by suitable detection, amplification and/or regeneration and reintroduction as and when necessary.

In preferred embodiments, full duplex facilities are provided i.e. signals may be transmitted and/or received in all directions simultaneously.

A network according to the first aspect of the present invention may be used for many speech and/or data transmission purposes, such as remote reading of electricity meters, remote banking and shopping, energy management systems, telephony (voice), switched telephony, security systems and/or interactive data services and television.

In a second aspect, the present invention provides a "network conditioning unit" for use with a network according to the first aspect of the present invention. The network conditioning unit includes a low pass filter portion or portions for filtering out the low frequency high amplitude mains power signal, a coupling element for input and removal of telecommunication signals from the network and, preferably, a terminating element of similar impedance to the characteristic impedance of the network at that point.

The use of such a unit ensures that the high frequency telecommunications signals do not contaminate the internal low voltage wiring present inside a premises, and/or that noise

sources from the internal low voltage premises wiring do not contaminate or corrupt the high frequency telecommunications signals being transmitted over the external electricity transmission and/or distribution network.

Preferably, the variable electrical loading effects (i.e. the load impedances) of all items which are coupled onto the network, from time to time and which utilise electrical energy (i.e. the electrical loads) are isolated from the communications signals by the action of low pass filter elements of the conditioning unit(s).

Preferably an electrical filter is used at the interface between the external distribution network and the internal network of the premises, e.g. a house, of a user to ensure that the two signals are separated. Such a filter should have minimal effect on the normal domestic electricity supply.

The filter element of the present invention, which aims to reduce telecommunications signals entering the internal network of a users premises, preferably has no more than 1 volt dropped across it whilst supplying a 100amp load from a 240v, 50HZ, single phase source.

Preferably the network conditioning unit provides impedance matching between reception/transmission devices and the power network. Additionally the network conditioning unit can carry full load or fault current at power frequencies whilst still carrying the voice and data signals.

In a third aspect, the present invention provides a method of signal transmission including input of a telecommunication signal having a carrier frequency of greater than approximately 1MHz onto an electricity power transmission and/or distribution network, and subsequent reception of the signal.

Where signals are being transmitted along a three phase electricity power cable, the signal propagation may be between any or all of the phases and ground. In the preferred embodiment

the signal is injected between only one of the phases and ground, and this provides unbalanced transmission characteristics and the cable behaves as a pseudo coaxial transmission line.

A wide range of different transmission techniques are available for use with electricity power line communication each using various modulation methods including both frequency and time division multiplexing. It has been determined that the spread spectrum method offers inherent security and good interference rejection characteristics. These properties are achieved using a large band width and hence requires the design of a specific filter.

The network conditioning unit preferably includes a low pass filter comprising a main inductor arranged between a mains electricity input and a mains electricity output and connected at each end thereof to a signal input/output line which is arranged in parallel to the mains electricity input and mains electricity output, the two connections including a first capacitor and a second capacitor each of a predetermined capacitance depending upon the portion of the frequency spectrum which is to be utilised for communications purposes.

In this arrangement the main inductor is operative to prevent communications signals from the signal input/output line from entering the domestic/industrial premises. This inductor is therefore preferably of a high inductance such as 10 μ H to 200 μ H for frequencies of 1MHz and above.

The first capacitor which connects the mains electricity input and the signal input/output line acts as a coupling capacitor to allow communication signals through from the signal input/output line whilst attenuating all low frequency components at or about the main electricity supply frequency (ie., 50/60Hz).

The second capacitor arranged between the mains electricity output and the signal input/output line provides a further attenuation of communication signals and is connected via the signal input/output line to ground.

SECRET

In the event of failure of either the first or second capacitor each such capacitor is preferably provided with a respective fuse arranged between the first or second capacitor and the signal's input/output line. Furthermore an additional safety precaution can be incorporated by provision of a second inductor arranged between the connections between the signal input/output line and the first and second capacitors. This inductor has no effect on communication frequency signals but will provide a path to ground if the first capacitor develops a fault thereby allowing the first fuse to blow without allowing the power frequency signal onto the signal input/output line.

The inductance of the main inductor depends upon the material of which it is made and the cross-section of the wire wound around the core. The $10\mu\text{H}$ inductance previously specified is preferably a minimum and with use of better core material a higher inductance, for example of the order of $200\mu\text{H}$, can be obtained. Alternatively, a number of inductors connected in series could be used.

The coupling capacitor has a capacitance preferably in the range 0.01 to $0.50\mu\text{F}$ and the second capacitor linking the mains electricity output with the signal input/output line and ground has a capacitance preferably in the range of 0.001 to $0.50\mu\text{F}$.

The second inductor arranged on the signal input/output line preferably has a minimum inductance of approximately $250\mu\text{H}$. This inductor therefore has no effect on communication frequency signals on the signal input/output line. The conductor used to construct the $250\mu\text{H}$ inductor should be of sufficient cross-sectioned area to take fault current should the decoupling capacitor fail to short circuit condition.

Preferably, any spurious or self resonance in the inductive or capacitive elements are avoided.

In a preferred embodiment the filter is assembled in a screened box so as to provide a good earth and prevent radiation of the communication signals.

Embodiments of the present invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a schematic diagram of a part of a network according to aspects of the present invention;

Fig. 2 is a schematic diagram of a first transmission system for a network according to the present invention;

Fig. 3 is a schematic diagram of a second transmission system for a network according to the present invention;

Fig. 4 is a schematic diagram of a third transmission system for a network according to the present invention;

Fig. 5A is a cross section through a typical three phase cable;

Fig. 5B is a section through a typical coaxial cable;

Fig. 6 is a preferred embodiment of a network conditioning unit according to an aspect of the present invention;

Fig. 7 is a second embodiment of a network conditioning unit according to an aspect of the present invention;

Fig. 8 is a plan view of a network conditioning unit;

Fig. 9 is a view of a circuit board for the network conditioning unit of Fig. 8.

Fig. 10 is a schematic diagram of a network conditioning unit according to the present invention.

Fig. 1 shows generally a network 40. Mains electricity enters the network from an 11kv transmission line 42, via a transformer 44 and onto a 415v three phase network 46. The 415v three phase network is supplied to a number of locations, such as buildings 48. Each of these buildings may receive only a single phase electricity supply or alternatively may receive a three phase

power supply.

Voice and data signals may be injected into the network (or alternatively received from the network) at an injection point 50, to be received by users in the premises 48. In order to separate the voice and data communication signals from the low voltage high amplitude power signal each signal destination is provided with a network conditioning unit 52. This network conditioning unit includes a low pass filter for separating out the two signals.

Fig. 2 shows a portion of a three phase network 40 into which and from which data signals may be transmitted and received using the network conditioning units 52. As an example, data signals could be transmitted onto the yellow phase of the network by network conditioning unit 52A i.e., the signal is applied between the yellow phase and earth as shown. The transmitted data may then be received by any or all of conditioning units 52B, 52C and 52D which are connected to the yellow, red and blue phases respectively. In other words transmitted data may be picked up on any phase of the cable, including the phases onto which the signals were not injected by the transmitting unit. This is due to the mutual capacitance between the phase conductors producing an effectively pseudo-coaxial nature of the three phase cable. As can be seen, data can be transmitted and received by each unit.

Fig. 3 shows a portion of a three phase network 40 into which and from which data signals may be transmitted and received using four network conditioning units 52. As shown, the data signals are transmitted across two phases of the three phase network - in this case the red and blue phases.

In Fig. 4 an alternative transmission system to Fig. 2 is shown, in which the data signals are transmitted across all three phases, i.e. blue, red and yellow, of the three phase network 40.

Fig. 5A shows a simplified cross section of a three phase power cable 54, including red phase 56, yellow phase 58, and blue phase

60. Data signals are transmitted between blue phase 60 and earth 62, and are injected into the network via network conditioning unit 52. At high frequencies, the mutual capacitance between the phases effectively produces a short circuit. Therefore, such a transmission system gives a pseudo-coaxial characteristic, roughly equivalent to the coaxial cable shown in Fig. 5B. The mutual capacitance between any two of the phases in the three phase cable is shown schematically as 64 in Fig. 5A - similar mutual capacitance exists between other parts of phases.

Referring to Fig. 6 an embodiment of a filter according to an aspect of the invention is indicated generally by the reference numeral 10 and is connected between a mains electricity input 12 and a mains electricity output 14. A signal input/output line 16 is also connected into the filter. The mains power line is a standard 50Hz mains electricity power supply providing a domestic electricity power source of 240v at a maximum current of 100 amps for normal usage.

The filter 10 is assembled into a metal box which prevents radiation of the communication signals to externally located appliances and which provides a connection 18 to earth for the signal input/output line 16. The filter 10 includes a first or main inductor 20 formed of 16mm^2 wire wound on a 10mm diameter, 200mm long ferrite rod with 30 turns of wire therearound. This provides an inductance of approximately $50\mu\text{H}$. This may be a minimum for the signal characteristics utilised. The use of better materials or a plurality of series inductors would increase the inductance of the inductor up to, for example, approximately $200\mu\text{H}$.

Each end of the main inductor 20 is provided with a connection to the signal input/output line 16. A first connection 22 between the mains electricity input 12 and signal input/output line 16 comprises a first or coupling capacitor 24 having a capacitance of between 0.01 and $0.50\mu\text{F}$ preferably $0.1\mu\text{F}$. This coupling capacitor 24 is connected to a first fuse 26 which is arranged to blow in the event of failure or a fault developing in capacitor 24.

A second connection 28 includes a second capacitor 30 having a capacitance of between 0.001 and 0.50 μ F, preferably 0.1 μ F. This capacitor provides further attenuation of the communication signals by shorting to the earth or ground 18. A second fuse 32 is provided to blow if a fault develops in the second capacitor 30 thereby preventing further unit damage.

The signal input/output line 16 includes a second inductor 34 having an inductance of approximately 250 μ H minimum. This inductor is provided as a damage limiter in the event of failure of the coupling capacitor 24. In the event of such failure this inductor provides a path to the ground 18 for the 50Hz mains electricity power frequency thereby blowing fuse 26. The inductor has no effect on the communication frequency signals present on the signal input/output line 16.

Fig. 7 shows a second embodiment of a filter according to an aspect of the present invention. The filter 70 includes a pair of inductors L1, L2 arranged in series between a mains electricity input 72 and a mains electricity output 74. A preferred value for L1 and L2 is approximately 16 μ H. Connected between the RF input line 80 and the mains input 72 is a first fuse F1 and capacitor C1, and connected between the RF input 80 and ground is a third inductor L3, which acts as an RF choke and has a typical value of 250 μ H.

Connected in a similar fashion between the connection point of L1 and L2 and ground is a second fuse F2 and second capacitor C2. Connected between the mains electricity output 74 and ground is a third fuse F3 and third capacitor C3. Typical value for the capacitors is around 0.1 μ F and for the fuses approximately 5 amps HRC.

Turning to Fig. 8 a typical housing arrangement for a network conditioning unit according to an embodiment of the present invention is shown. The main inductors L1 and L2 are housed within a shielding box 90. Various connections are shown, including a communication interface port 92 to which a user's communication equipment would normally be connected. However, as

shown in Fig. 8, this port may be terminated in an impedance matching port terminator 94.

Fig. 9 shows a circuit board 96 which fits inside the unit 90 of figure 8 and houses the rest of the circuitry for the network conditioning unit of figure 7. Connections A, B, C, D and E are shown which connect to the appropriate points of the box shown in figure 8.

Fig. 10 is a schematic representation of a network conditioning unit 52, showing the various building blocks 80-86 of the network conditioning element. To design a suitable network conditioning unit, the circuits represented by blocks 81 and 86 should be high-impedance elements over the required communications frequency spectrum (eg. 1MHz and above) and low impedance elements at frequency of mains electricity supply (ie. 50/60HZ) ie. these elements are inductors. Similarly blocks 80 and 82 should be low impedance coupling elements over the required communications frequency spectrum and high impedance isolating elements at the frequency of the mains electricity supply ie. they are capacitors.

HRC fault current limiting fusible safety links (84 and 85) are provided in series with elements 80 and 82. An additional impedance matching network 83 may be included for connection to a communications port. This element may be external to the network conditioning unit 52.

The optimum values of items 81, 80, 82 and 86 will be dependant upon factors including:-

- a) The required frequency range over which the network is to be conditioned.
- b) The unit length of the network which is to be conditioned.
- c) The number and types of loads which may be encountered on the network.

d) The characteristic impedance of the network phase conductors with respect to earth ie. conductor outer electrical sheath.

e) The impedance of the communications interface devices.

The network conditioning unit may be filled with air, inert gas, resin compound or oil depending upon the location and load and/or fault current ratings of the conditioning unit. Also it may be sited indoors, pole mounted, buried underground or inserted in street lamp columns.

Similarly items 81 and 86 may comprise of a number of individual inductors in series, and if no interconnection is required, for example, on a street light, items 84, 80, 83 and 86 may be omitted.

Items 80 and 82 may comprise of a number of capacitors in series and/or parallel configuration depending upon working voltages encountered ie. 240, 415, 11kV, 33kV etc. Alternatively, or additionally, items 80 and 82 may comprise of two or more capacitors in parallel in order to overcome, for example, deficiencies in capacitor design when conditioning a network over a relatively wide frequency range, for example 50 MHz to 500 MHz.

Furthermore, items 81, 85 and 82 of the network conditioning unit may be cascaded if required. In a typical design, the greater the number of cascaded elements the sharper will be the roll off response of the filter.

It will be seen from the foregoing that the invention provides a simple filter effectively separating signals having a frequency spectrum indicative of radio communication signals from those of standard mains electricity power supply without significant loss of power or quality in either signal. Thus the electricity distribution and/or transmission networks can be used for both the provision of electricity supply and the propagation of telecommunication signals.

The use of a filter according to the invention at each consumer

The invention is not confined to the foregoing details and variations may be made thereto within the scope of the invention.

CLAIMS:

1. An electricity distribution and/or power transmission network including input means for the input onto the network of a telecommunication signal having a carrier frequency greater than approximately 1MHz and output means for removing said telecommunication signal from the network.
2. A network according to claim 1 in which signals are transmissible in a plurality of directions simultaneously.
3. Communications apparatus for use with an electricity power distribution and/or transmission network, including a low pass filter portion for filtering out a low frequency high amplitude mains electricity power signal, and a coupling element for input and/or removal of a telecommunication signal from the network.
4. Communications apparatus according to claim 3 wherein the coupling element is suitable for use with a telecommunication signal having a carrier frequency of greater than 1MHz.
5. Communications apparatus according to claim 3 or claim 4 including a terminating element for terminating the apparatus in a similar impedance to the characteristic impedance of the network at that point.
6. Communications apparatus according to any one of claims 3, 4 or 5 including impedance matching means for impedance matching between reception/transmission devices and the electricity power distribution and/or transmission network.
7. A method of signal transmission including input of a telecommunications signal having a carrier frequency of greater than approximately 1MHz onto an electricity power distribution and/or transmission network, and subsequent reception of the signal.
8. A method according to claim 7 wherein the signal is injected onto only one of the phases of a three phase power cable.

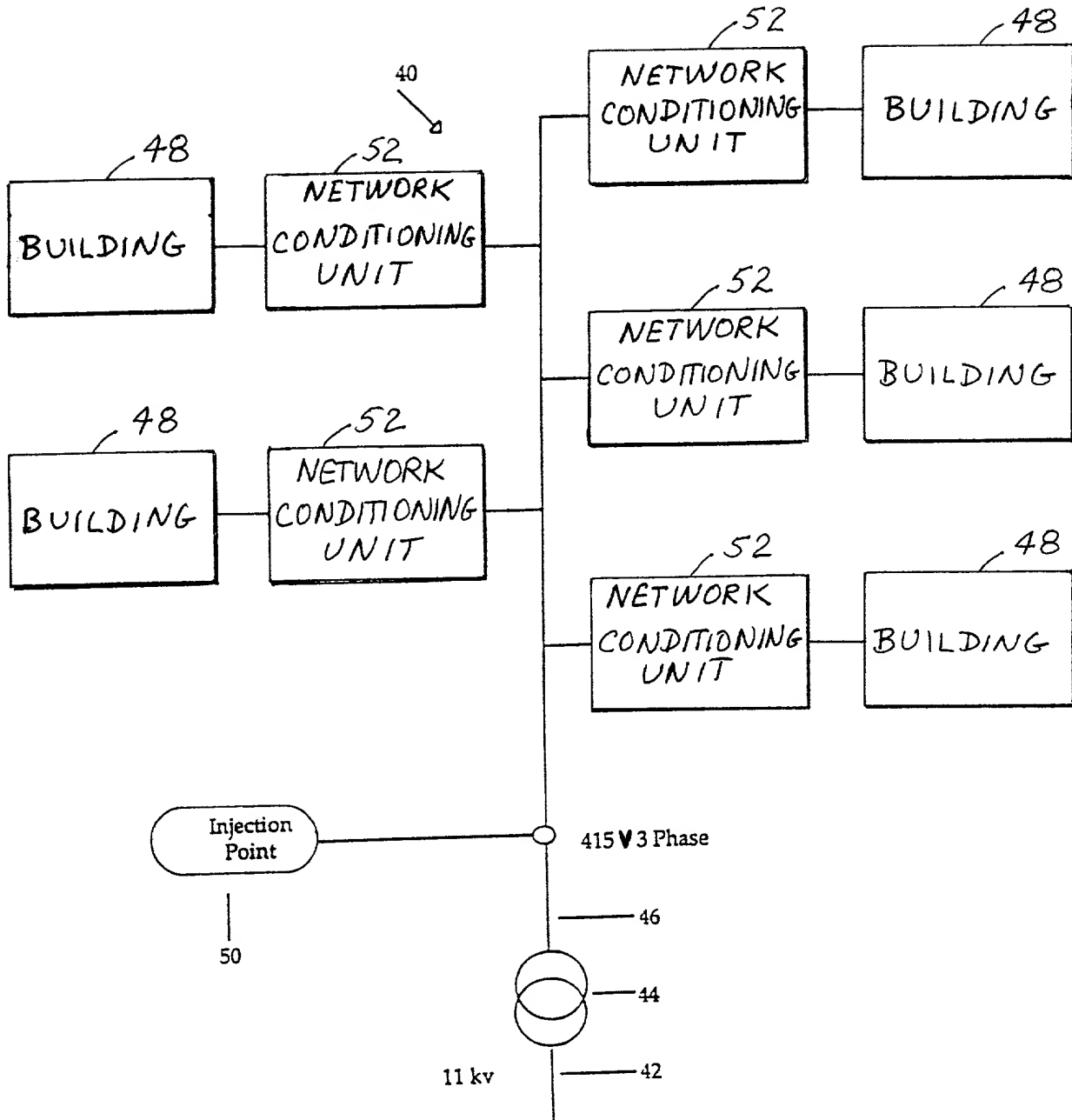
TRANSMISSION NETWORK AND FILTER THEREFORABSTRACT (FIG. 1 TO ACCOMPANY)

A power transmission network (40) is disclosed which includes input means (52) for the input of telecommunication signals having carrier frequencies greater than 1MHz onto the network (40), and a means for removing similar speech and/or data signals from the network.

Preferably a network conditioning element (52) is used which includes a low pass filter portion for filtering out a low frequency high amplitude mains power signal, and a coupling element for input and/or removal of telecommunication signals from the network. In this way both speech and data signals can be transmitted at carrier frequencies of greater than 1MHz along a standard electricity distribution and/or transmission network which when conditioned provides a larger available spectrum per unit length of network and greater transmission capacity than previously known. The quiescent noise level of the conditioned network is also much reduced thus permitting lower signal injection levels for a given signal-to-noise ratio and a consequential reduction in spurious radiation from the network.

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FIG.1



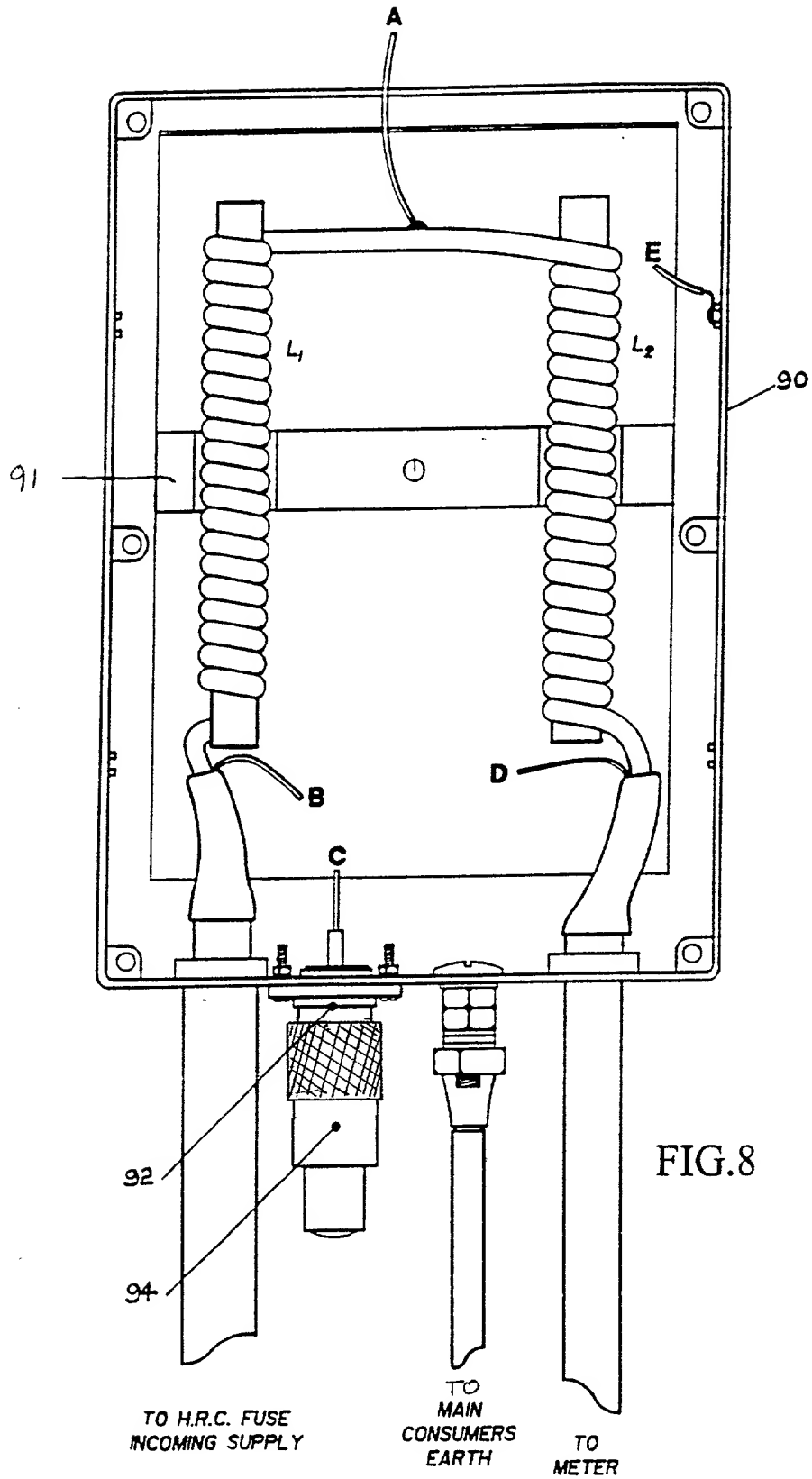


FIG.8

FIG.9

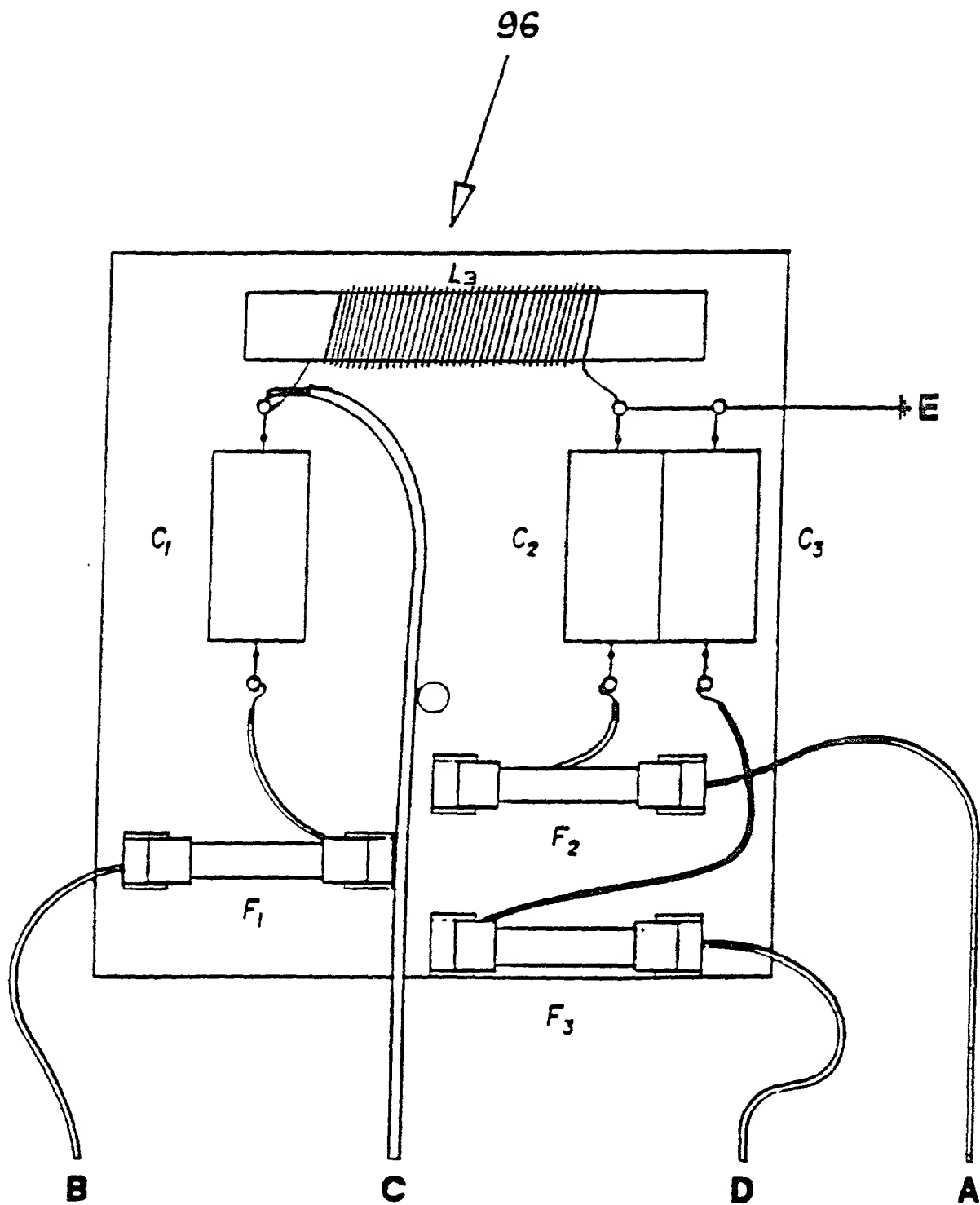


FIG. 10

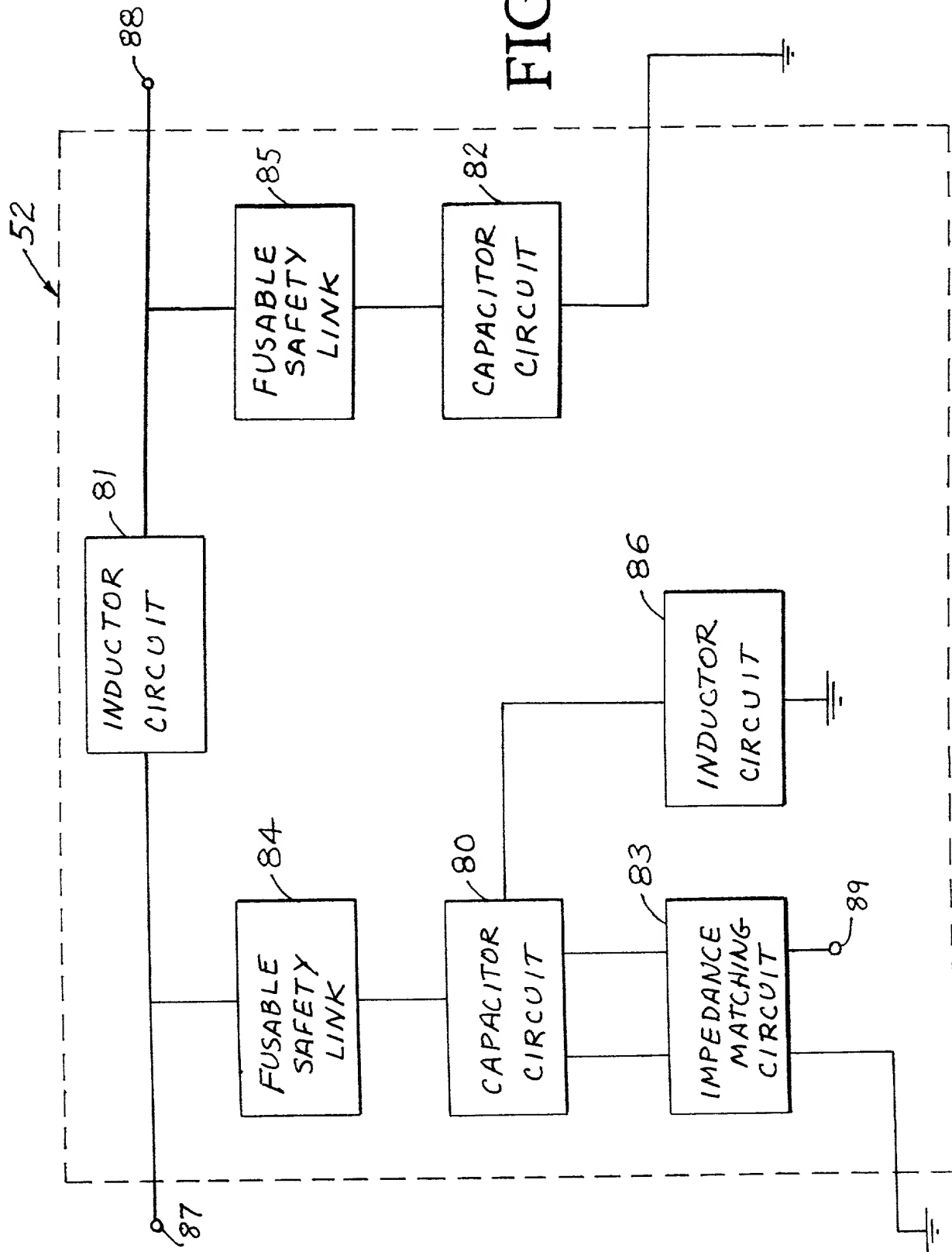
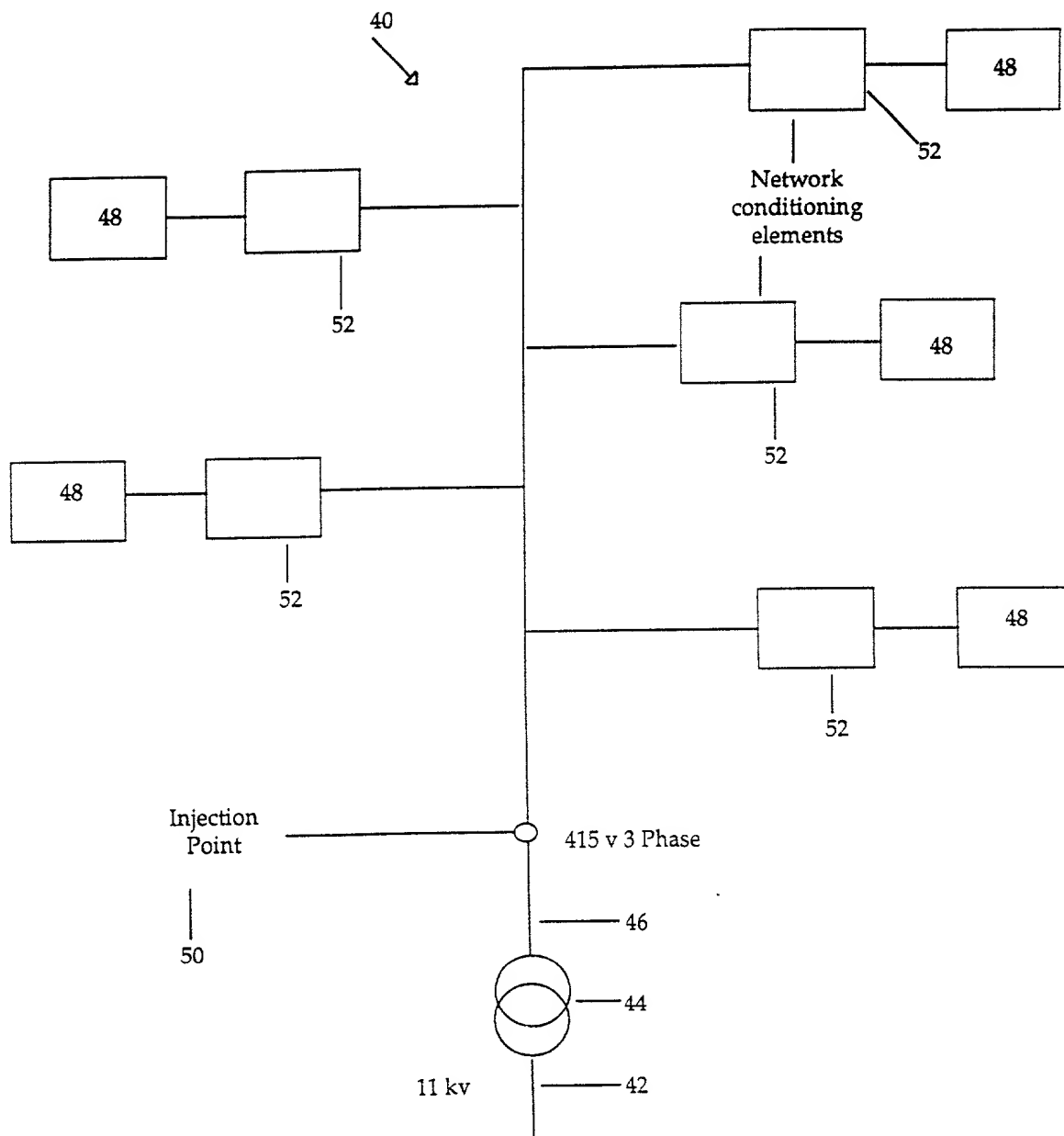


FIG.1/10



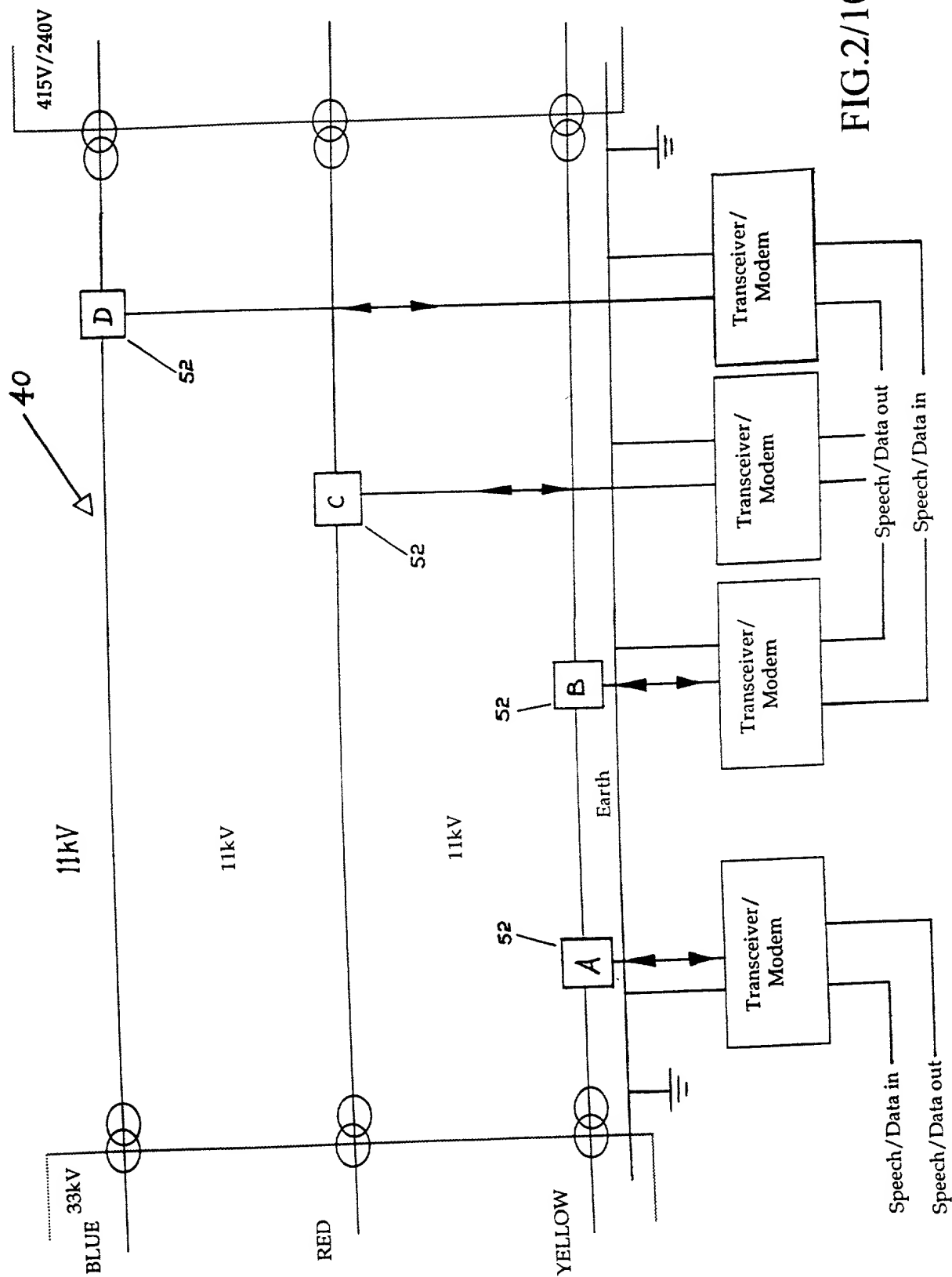


FIG.3/10

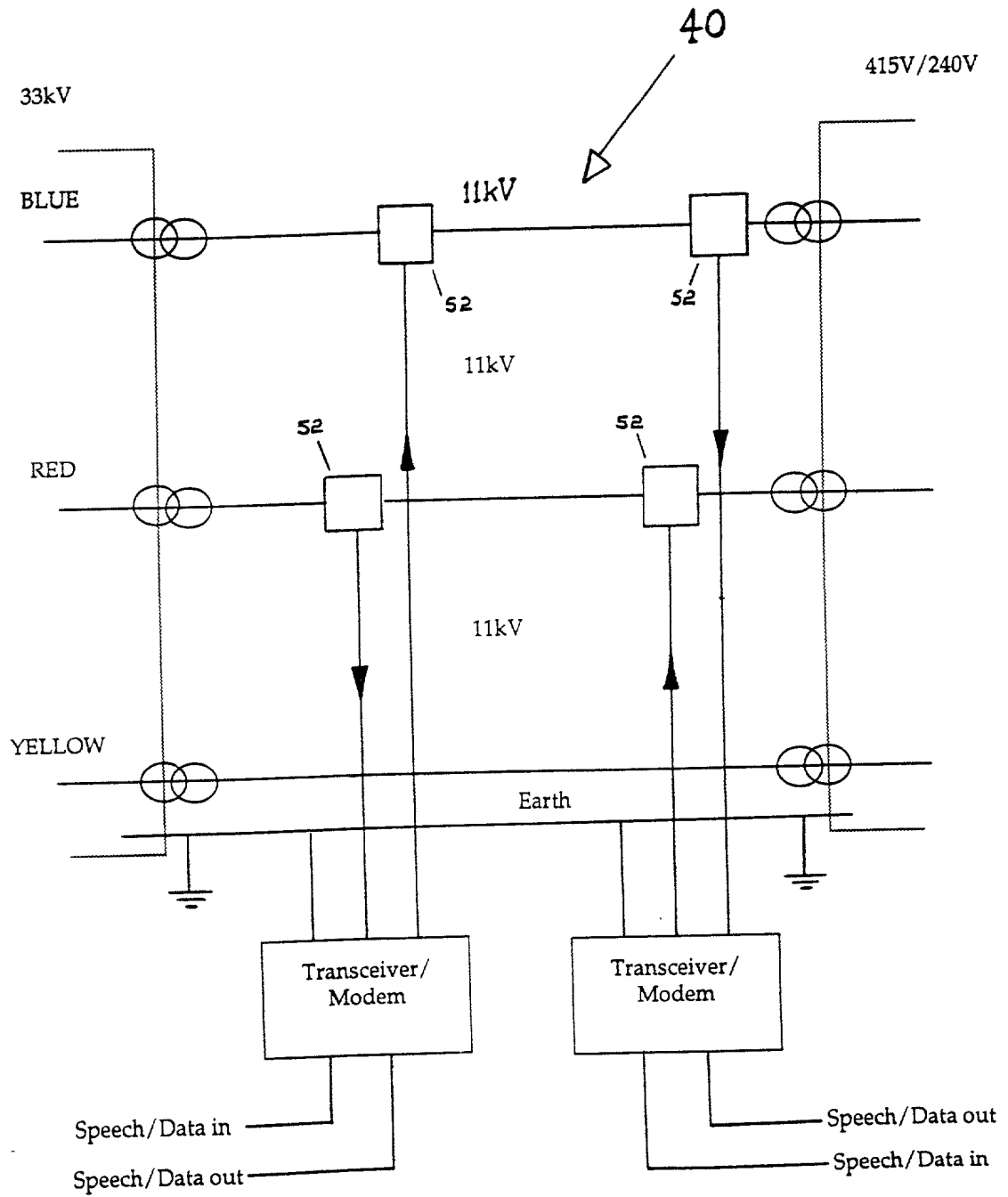
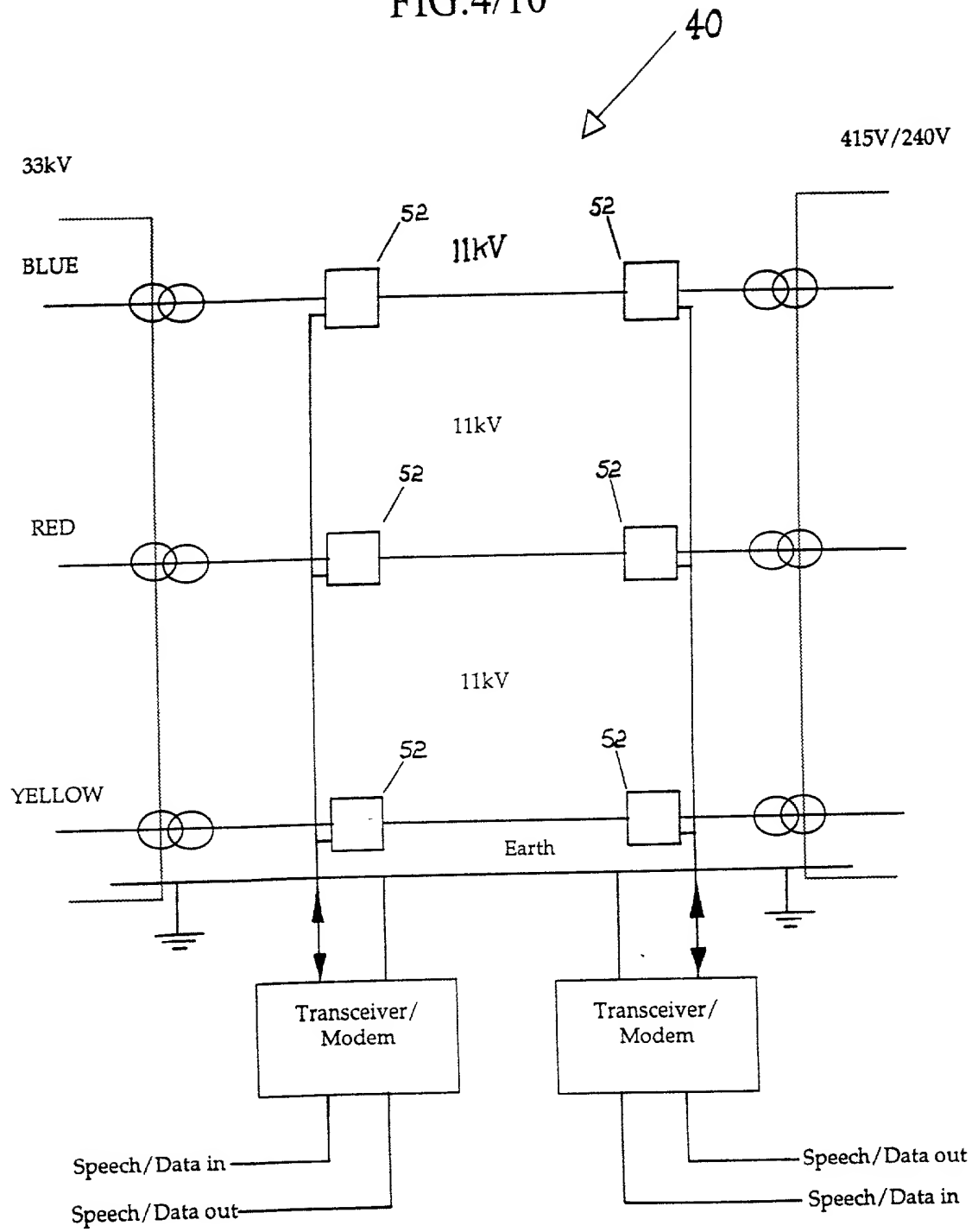


FIG.4/10



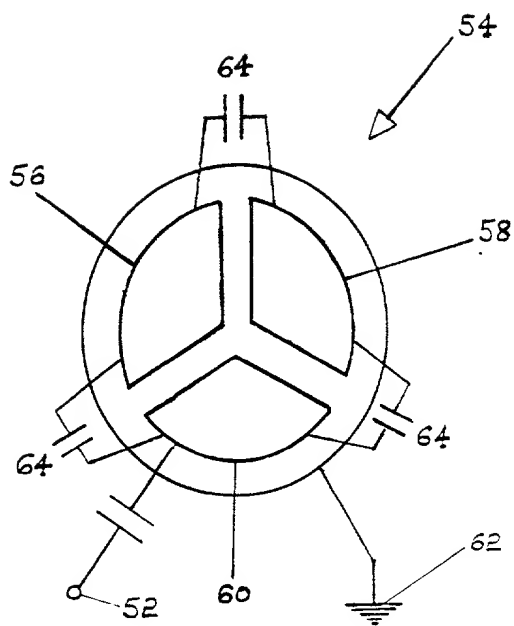


FIG. 5/10A

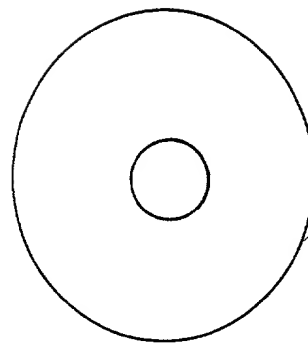


FIG. 5/10B

FIG.6/10

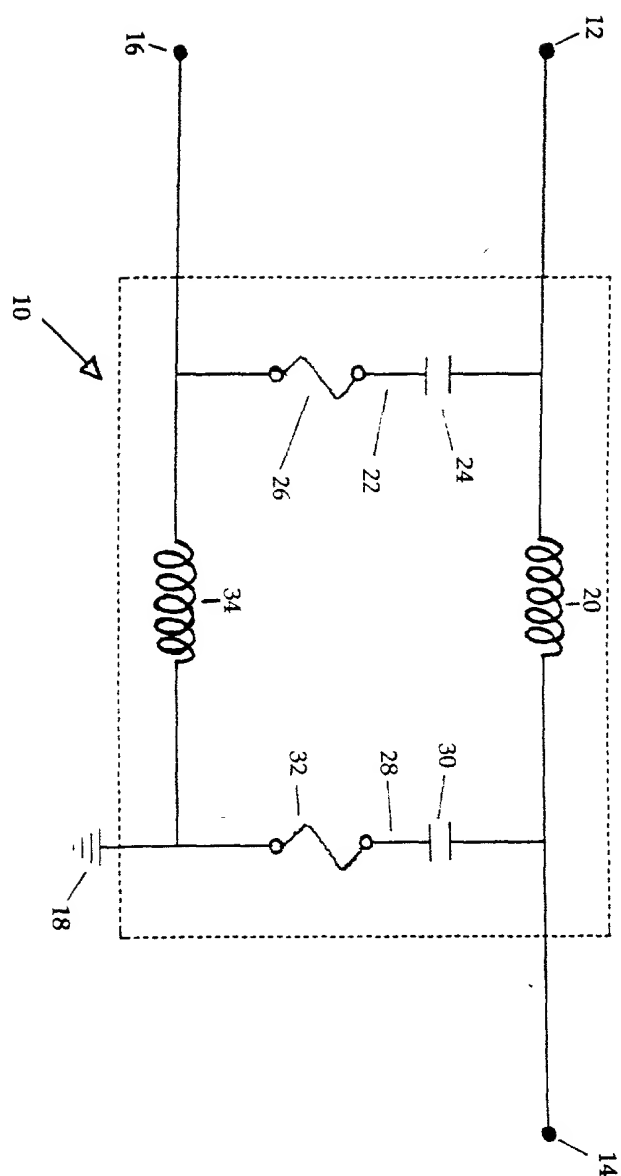


FIG. 7/10

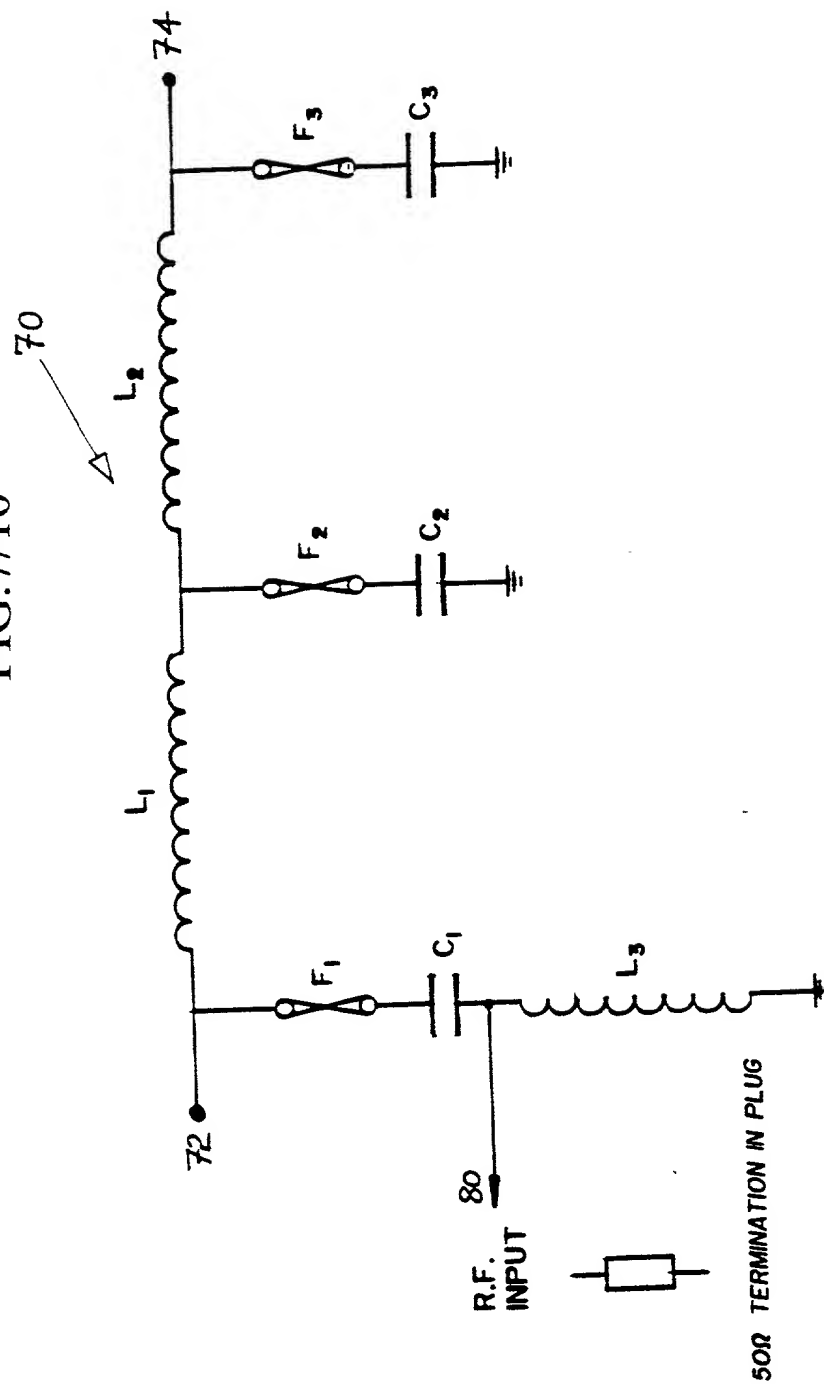


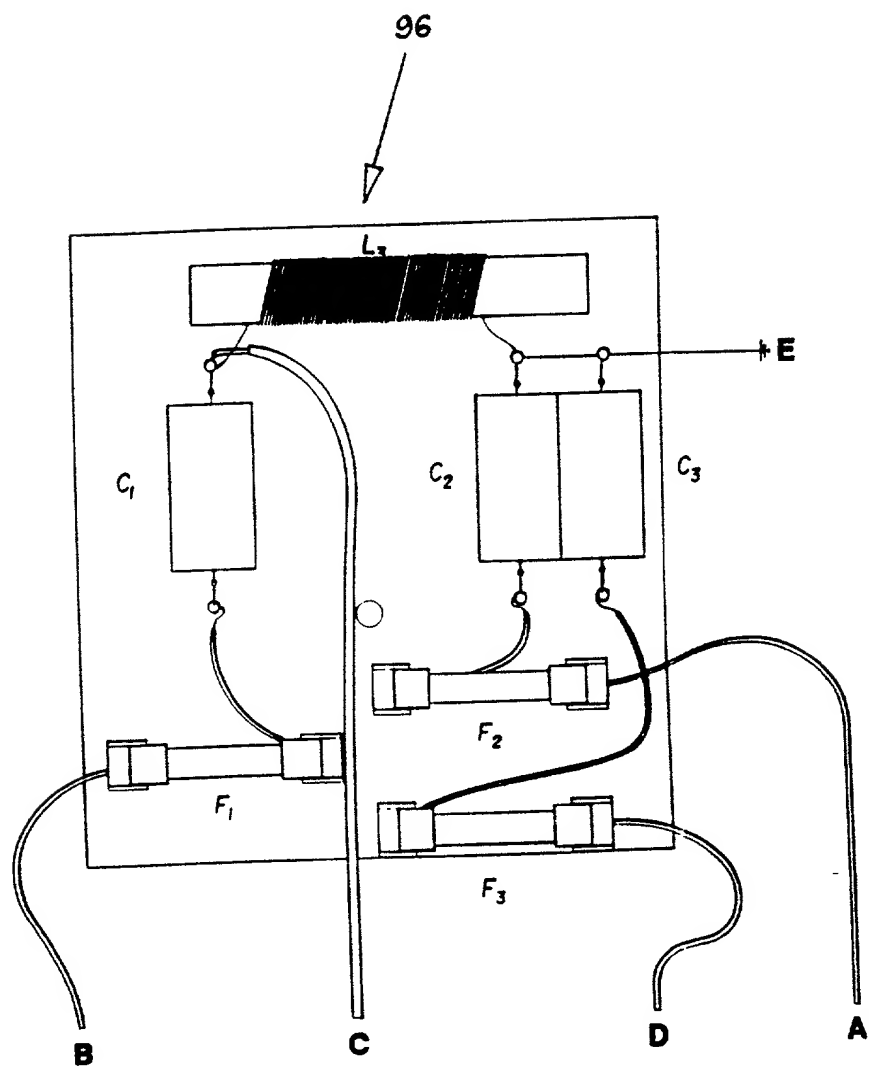
FIG. 8/10

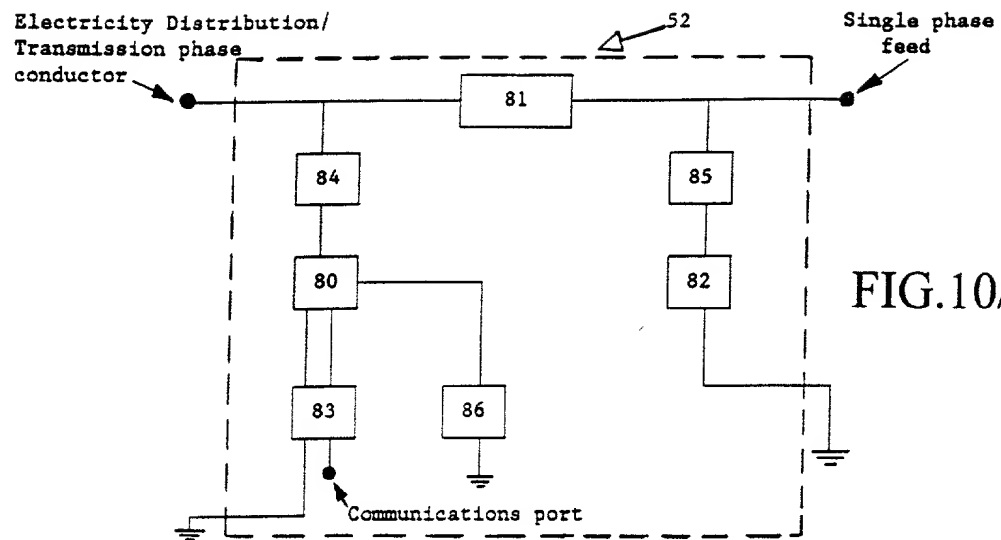
TO H.R.C. FUSE
INCOMING SUPPLY

MAIN
CONSUMERS
EARTH

TO
METER

FIG.9/10





COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY

(Includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TRANSMISSION NETWORK AND FILTER THEREFOR

the specification of which (check only one item below):

☐ is attached hereto.☐ was filed as United States application

Serial No. _____

on _____

and was amended

on _____ (if applicable).

☒ was filed as PCT international applicationNumber PCT/GB93/02163on 20 OCTOBER 1993

and was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day month year)	PRIORITY CLAIMED UNDER 35 USC 119
			<input type="checkbox"/> YES <input type="checkbox"/> NO
UNITED KINGDOM	GB 9222205.8	22 OCTOBER 1992	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

Combined Declaration For Patent Application and Power of Attorney (Continued) <small>(Includes Reference to PCT International Applications)</small>				ATTORNEY'S DOCKET NUMBER
<p>I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:</p>				
PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:				
U S APPLICATIONS			STATUS (Check one)	
U S APPLICATION NUMBER	U S FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U S				
PCT APPLICATION NO	PCT FILING DATE	U S SERIAL NUMBERS <small>ASSIGNED (if any)</small>		
PCT/GB93/02163	20 October 1993			
<p>POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)</p> <p style="text-align: center;">Richard C. Auchterlonie, Reg. 30,607</p>				
<p>Send Correspondence to: Richard C. Auchterlonie ARNOLD, WHITE & DURKEE P. O. Box 4433 Houston, TX 77210-4433</p>			<p>Direct Telephone Calls to: <small>(name and telephone number)</small></p> <p style="text-align: center;">(713) 787-1698</p>	
201	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
		BROWN	PAUL	ANTHONY
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
		KENDAL, CUMBRIA	UNITED KINGDOM	UNITED KINGDOM
202	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
		30 APPLERIGG	KENDAL, CUMBRIA	LA9 6EA (UK)
	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
203	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
<p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.</p>				
SIGNATURE OF INVENTOR 201		SIGNATURE OF INVENTOR 202		SIGNATURE OF INVENTOR 203
DATE		DATE		DATE
19 th October 1994.				

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

U.S. SERIAL NO.: _____	§	GROUP ART UNIT:
	§	
FILING DATE: _____	§	EXAMINER:
	§	
APPLICANT: Paul A. Brown	§	ATTY. DKT.: NRW:002--2
	§	
ORIGINAL TITLE:	§	
TRANSMISSION NETWORK	§	
AND FILTER THEREFOR	§	
	§	

REQUEST FOR PERMISSION TO AMEND DRAWINGS

Assistant Commissioner for Patents
Washington, D.C. 20231
Attention: Official Draftsperson

Dear Sir or Madam:

Applicant respectfully requests permission to amend the drawings as shown in red in the enclosed sketches of FIGS. 1, 8, 9, and 10 submitted in triplicate.

FIG. 1 has been amended to label the boxes 48 and 52. Buildings 48 are mentioned on the second line from the bottom of page 8 of the applicant's specification. Network conditioning unit(s) 52 are mentioned on lines 6 and 10 of page 9 of the applicant's specification. An oval has been drawn around "Injection point" 50 so that it should not be seen as descriptive matter. FIG. 1 has also been amended to change "415 v 3 Phase" to --415 V 3 Phase-- so that the unit of volts is designated by a capital V.

FIG. 8 has been amended to eliminate the descriptive matter "CONDUCTOR CLAMP," "COMMUNICATION INTERFACE PORT," and "COMMUNICATION PORT TERMINATOR". A reference numeral 91 has been added to designate the "conductor clamp" in order to transfer

Paul A. Brown

this descriptive matter to the specification. The word -- TO -- has been added just above "MAIN CONSUMERS EARTH" in order that the label "MAIN CONSUMERS EARTH" should not be seen as descriptive matter. Moreover, the solid black of the communication port terminator 94 has been replaced with a diamond knurl, as would be apparent to one of ordinary skill in the art.

In FIG. 9, the objectionable solid black is eliminated by showing spacing between the windings of the inductor L3 described at the end of the third paragraph on page 11 of the specification.

In FIG. 10, box 80 has been labeled -- CAPACITOR CIRCUIT --, box 81 has been labeled -- INDUCTOR CIRCUIT --, box 82 has been labeled -- CAPACITOR CIRCUIT --, box 83 has been labeled -- IMPEDANCE MATCHING CIRCUIT --, boxes 84 and 85 has been labeled - - FUSABLE SAFETY LINK --, and box 86 has been labeled -- INDUCTOR CIRCUIT --. Reference numerals 87, 88 and 89 have also been added to FIG. 10 in order to transfer the objectionable descriptive matter to the specification.

Signed at Houston in the County of Harris, and State of Texas, this 6th day of April, 1999.

Paul A. Brown

Respectfully submitted,



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Houston, Texas 77210
(713) 787-1400

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DATE OF DEPOSIT: 6 April 1999

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Washington, D.C. 20231



Signature